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# ILLINOIS STATE GEOLOGICAL SURVEY
## ITS HISTORY AND ACTIVITIES

Robert E. Bergstrom

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This booklet was prepared in observance of the 75th anniversary of the Illinois State Geological Survey. The Act creating the Geological Survey was approved by the Illinois General Assembly on May 12, 1905, and H. Foster Bain assumed direction of the Survey on November 1.

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# ILLINOIS STATE GEOLOGICAL SURVEY: ITS HISTORY AND ACTIVITIES

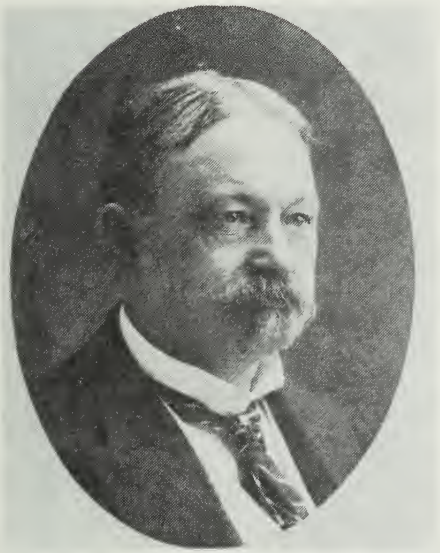
Robert E. Bergstrom

Educational Series 12
1980

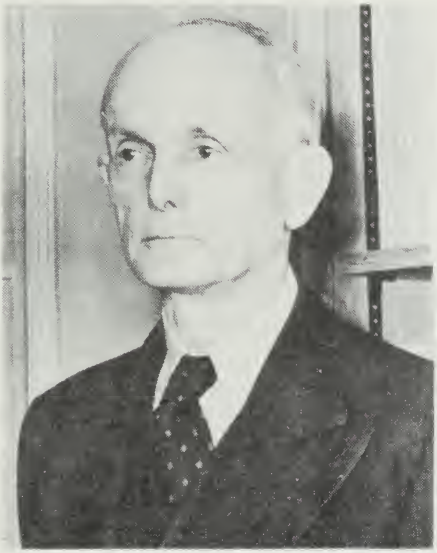
Illinois Institute of Natural Resources
STATE GEOLOGICAL SURVEY DIVISION, Urbana
Jack A. Simon, Chief

Joseph G. Norwood
State Geologist, 1851-1858

Amos H. Worthen
State Geologist, 1858-1888



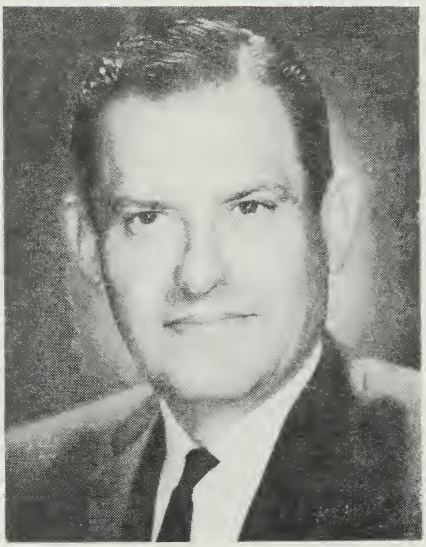
Josua Lindahl
State Geologist, 1888-1893



H. Foster Bain
State Geologist, 1905-1909

Frank W. DeWolf
State Geologist, 1909-1923

Morris M. Leighton
State Geologist, 1923-1954



John C. Frye
State Geologist, 1954-1974

Jack A. Simon
State Geologist, 1974-present

# ILLINOIS STATE GEOLOGICAL SURVEY:

## ITS HISTORY AND ACTIVITIES

### INTRODUCTION

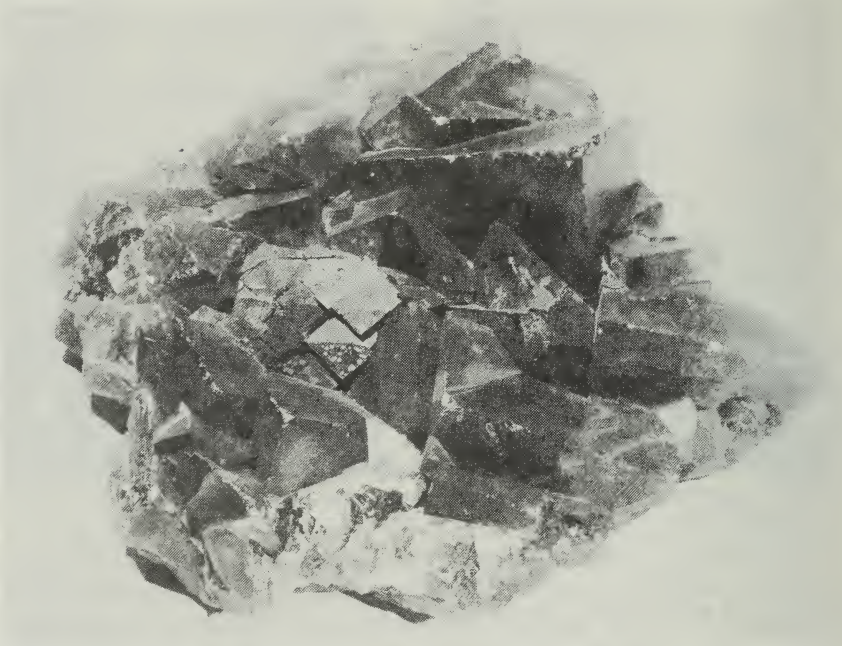
The Illinois State Geological Survey, a division of the Illinois Institute of Natural Resources, is charged with studying the geology and mineral resources of Illinois and reporting the results of these studies to its citizens. Established by the State General Assembly in 1905, the Geological Survey is observing its 75th anniversary in 1980. This booklet presents a summary of the history and activities of the Geological Survey. A more comprehensive history of the Survey, with extensive bibliography, is given by Hays (1980).*

The Geological Survey is one of three scientific surveys located on the campus of the University of Illinois in Urbana; the other two are the State Natural History Survey and the State Water Survey. Although these surveys are not part of the University of Illinois, by law they have cooperative relationships and they have traditionally had close ties with the University in research, personnel, and facilities.

Geological Survey activities include basic and applied research, public service, data collection, and publication of maps and research reports. These activities are carried out by a staff of approximately 160 scientists and support personnel, plus about 50 scientists employed on a temporary basis to work on various projects funded through the University of Illinois by outside (principally federal) agencies. The scientific staff consists mainly of geologists and chemists (organized adminstratively into a Geological Group and a Chemical Group), but also includes engineers and mineral economists. Each group is subdivided into specialty sections. Editors, draftsmen, typists, clerks, accountants, computer programmers, and other support staff are included in an Administrative Group. The appropriation for operation of the Geological Survey in fiscal year 1981 was 3.77 million dollars.

Most of the Survey offices and laboratories are located in the Natural Resources Building (at Peabody Drive and Sixth Street), a four-story building shared with the State Natural History Survey. Pilot-project facilities, particularly for coal research, are housed in the Applied Laboratory on the western edge of the campus (Gregory and Oak Streets). The Natural Resources Studies Annex, also shared with the State Natural History Survey, is a relatively new building used principally for storage of large collections of drill hole samples and rock, mineral, and paleontological specimens of the Geological Survey. The building is located southwest of the Assembly Hall south of St. Mary's Road (Griffith Drive and Hazelwood). A small field office in Warrenville, Illinois (shared with the State Water Survey), serves the public in northeastern Illinois.

* Hays, Robert G., 1980, State Science in Illinois. The scientific surveys, 1850-1878: Southern Illinois University Press, Carbondale and Edwardsville, IL, 257 p.



**Fluorite, state mineral.** Specimen showing characteristic cubic crystals.

**Specimen from Worthen collection.** Embedded specimens of *Taxocrinus sp.* (crinoid) from the St. Louis Formation (Mississippian) at Hardin County, Illinois.

## HISTORY OF THE SURVEY

The present Geological Survey, established in 1905, is actually the State's second Geological Survey. The first Survey was in existence from 1851 until 1875.

In creating the Geological Survey in 1851, the State General Assembly directed the State Geologist to study the stratigraphy and structure of Illinois, discover its mineral resources, make chemical analyses of the rocks and minerals, determine the topography of the state, submit annual progress reports and a final report to the governor, and collect rock, mineral, and fossil specimens for a state collection. The act appropriated $3,000 per year for the work of the Survey, and in 1853 the appropriation was increased to $5,500 per year.

Dr. Joseph G. Norwood, the first State Geologist, was trained as a physician, as were many geologists of this era. From 1851 until 1855 Norwood operated the Illinois Survey from headquarters in New Harmony, Indiana, an influential scientific community headed by geologist David Dale Owen, who directed a number of federal surveys of geology and mineral resources for the General Land Office. Norwood's facilities at New Harmony included an analytical chemical laboratory reputed to be the best-equipped laboratory of any geological agency in the country. In 1855 Dr. Norwood, under pressure from the Illinois legislature, moved the Survey to Springfield, Illinois.

In 1858 Dr. Norwood was succeeded by Amos H. Worthen, a businessman from Warsaw, Illinois. A fossil and mineral collector and self-taught geologist, Worthen eventually became one of the leading geologists of his time. He began his professional geological career by serving on Norwood's staff and on the staff of the Iowa Geological Survey under James Hall. During this period he became familiar with the geology and paleontology of Illinois and southeastern Iowa. Worthen's fossil collection, one of the largest in the Midwest, later became a substantial part of the holdings of the early State Museum.

As State Geologist, Worthen enlisted outstanding geologists and paleontologists to study the geology, paleontology, and mineral resources of Illinois. Among these were H. M. Bannister, F. H. Bradley, G. C. Broadhead, E. T. Cox, Henry Englemann, H. C. Freeman, H. A. Green, and James Shaw. Paleontologists included Worthen, Leo Lesquereux, F. B. Meek, S. A. Miller, J. S. Newberry, Orestes St. John, S. H. Scudder, Charles Wachsmuth, and Frank Springer.

The results of the investigations of this group of scientists, often referred to as the Worthen Survey, were published between 1866 and 1890 in eight massive volumes totaling 4,761 pages of text, figures, and plates. (The last volume was issued two years after Worthen's death.) The volumes contained descriptions of Illinois landforms and their underlying rock layers; descriptions of the geology of the lead region and the coal fields; chemical analyses of Illinois rocks and waters; and summaries of the geology and mineral resources of all the counties in Illinois except DeWitt. Also included in the volumes was Worthen's 1875 geologic map of Illinois, which outlined the boundaries of the major rock units recognized today. In the Worthen volumes, the major coal seams were identified, assigned numbers, and correlated throughout the state. Also described and pictured in the volumes were 1,626 species of fossils, nearly 1,500 of which were new species. In 1882, three volumes titled *Economical Geology of Illinois*

were published, consisting of the 101 county summaries reprinted from the first six volumes of the Worthen Survey.

In 1875, when the sixth volume, completing the county reports, had been published, the Illinois General Assembly considered the work of the Geological Survey to be completed, and did not re-appropriate funds to continue it. For the next two years Worthen continued working without pay on the Survey collections in the basement of the Springfield Post Office. (The Survey had moved to the Post Office following a fire that destroyed its offices in the Masonic Hall in 1871. Worthen's son Charles, who was sleeping in his father's office during the night the fire broke out, removed his father's library and collection before the fire reached the office.)

Worthen was State Geologist and curator of the State Historical and Natural History Museum (established in 1877) until his death in 1888. His successor, Professor Josua Lindahl of Augustana College, who also served as State Geologist, edited Volume VIII of the Worthen Survey, published in 1890.

From 1875 until 1905 geological studies in Illinois continued without coordination by a state agency (except for the work done by Worthen and Lindahl at the State Museum). However, important research was done during this period by a number of geologists, including Professor Thomas C. Chamberlin, University of Chicago, Professor Charles W. Rolfe, University of Illinois, and H. Foster Bain and others of the U. S. Geological Survey. For example, the investigations of Chamberlin and Frank Leverett in the last two decades of the century showed that the drift, which had been discussed in detail in the Worthen volumes, was formed by continental glaciers that covered the upper Midwest, a concept that Worthen had considered but did not accept. Worthen believed that icebergs melting in a vast inland sea had caused mud and rock to drift from the North into the Midwest.

Partly through the efforts of Chamberlin (a neighbor and friend of Governor Charles S. Deneen), the Western Society of Engineers, and the University of Illinois, the General Assembly in 1905 established a State Geological Survey at the University of Illinois. The Survey was charged with four major responsibilities: (1) to study the geologic formation of the State, particularly as related to mineral resources; (2) to prepare geologic and other maps showing locations of its mineral resources; (3) to prepare reports of Survey investigations; and (4) to consider other scientific and economic questions the commissioners might believe valuable to the state. The Survey was to be governed by a three-member State Geological Commission consisting of Governor Deneen, the president of the University of Illinois, E. J. James; and an appointed member, Chamberlin. Chamberlin served on this Commission and its successor, the Board of Natural Resources and Conservation, until 1919. The initial appropriation for the Geological Survey in 1905 was $25,000 per year, with $10,000 of this amount earmarked for topographic mapping in cooperation with the U. S. Geological Survey. H. Foster Bain, of the U. S. Geological Survey, was appointed director of the new Illinois State Geological Survey.

Director Bain initiated many of the programs that are still being carried on today by the Geological Survey: mapping and study of the composition and character of Illinois coals; study of clays and fireclays; investigation of the geology of oil and gas fields; study of lead and zinc in Illinois; sampling of quarries and quarry products;

study of ground-water resources; studies of the rock sequences (stratigraphy) in Illinois; preparation of educational booklets; and collection of mineral statistics. A new state geologic map by Stuart Weller was published in 1906 as Bulletin No. 1 of the Survey.

Many of the Survey's programs were conducted by part-time consultants. Among these were Stuart Weller (stratigraphy) and R. D. Salisbury (educational bulletins) of the University of Chicago; Charles W. Rolfe (clays) and Samuel W. Parr (coal chemistry) of University of Illinois; U. S. Grant (lead and zinc) of Northwestern University; J. A. Udden (ground-water geology) of Augustana College; and W. S. Blatchley (petroleum geology), State Geologist of Indiana.

In 1906 Bain called a meeting in Chicago to organize the Mississippi Valley Association of State Geologists; this meeting led to the formation two years later of the Association of American State Geologists, an organization still active today.

Director Bain took a broad view of the kinds of studies the Survey should conduct in coal resources. In addition to the mapping of the coal fields and individual seams, he proposed study of the gas content in coal, mine roof and floor characteristics and other geologic factors affecting mining operations, mining technology and coal preparation methods, and the possibility of using Illinois coals for metallurgical coke. He asserted that a thorough knowledge of the character of the coal was a prerequisite for all coal studies. Gilbert H. Cady, who would be the Illinois Geological Survey's pre-eminent coal authority for more than 50 years, joined Bain's staff in 1907.

Under Bain's administration, topographic studies were made of drainage conditions in the bottom lands along the Kaskaskia, Big Muddy, Embarras, Wabash, and Sangamon Rivers. Statistics compiled on mineral production in Illinois for 1905, cited in Bain's administrative report for 1906, valued Illinois mineral production at 59.6 million dollars. Nearly 5,000 records from drill holes were added to the Survey files between 1905 and 1908 in response to the Survey's request for drilling data from mining companies, drilling firms, and individuals.

Bain resigned as director in 1909 and was succeeded by Frank W. DeWolf, former assistant director. Under DeWolf the programs initiated by Bain were expanded to keep step with the rapidly growing mineral industry in Illinois. In 1912 the value of Illinois mineral production, based mainly on the production of 51 million tons of coal and 30 million barrels of oil, reached 123 million dollars. Illinois ranked third among the states in both coal and oil production and held a virtual monopoly in the production of fluorspar in the United States.

In 1913 DeWolf and his colleagues organized an Illinois Mining Investigation under a cooperative agreement with the Engineering Experiment Station at the University of Illinois and U. S. Bureau of Mines. Geologists, mining engineers, and chemists carried on a systematic 10-year investigation. They inventoried coal resources, studied mining practices to improve safety and efficiency, and determined the physical and chemical characteristics of Illinois coal that affected its usability for fuel, for coking, and for manufacture of gas.

In 1917 the Illinois state government was reorganized under a new Civil Administrative Code that provided for nine executive departments in addition to the state elective offices. The three scientific surveys—along with the Illinois State Museum in Springfield—all became divisions of a newly created Department of Registration and

**First three chiefs of present Survey.** Morris M. Leighton, H. Foster Bain, and Frank W. DeWolf. (Photo, 1940.)

Education. The Department also included five state teachers colleges and a licensing division for trades and professions. Within this department, the Board of Natural Resources and Conservation was created to administer the scientific surveys. This board was composed of the director of the Department of Registration and Education (replaced in 1979 by the Director of the Institute of Natural Resources) as ex-officio chairman, the president of the University of Illinois and, since 1951, the president of Southern Illinois University, and one expert (with at least 10 years of experience) from the fields of geology, chemistry, engineering, plant biology, and animal biology. This board has guided the programs of the three Surveys ever since. Under the new adminstrative code the title of each Survey head was changed from Director to Chief.

World War I affected the direction of the Geological Survey's work. Although topographic mapping in cooperation with the U. S. Geological Survey was suspended, investigations for coal, oil, and gas, and fluorspar were intensified. Chief DeWolf took leave from the Geological Survey for duty with the Bureau of Mines and Professor Thomas E. Savage of the University of Illinois, an authority on the stratigraphy and paleontology of Illinois since the early days of the Survey, became acting Chief. After the war the Survey resumed topographic mapping (with increased impetus provided by the passage of a 60-million-dollar state bond issue to support construction of paved highways in the state). The Geological Survey instituted a major program for locating sand and gravel deposits for road building materials.

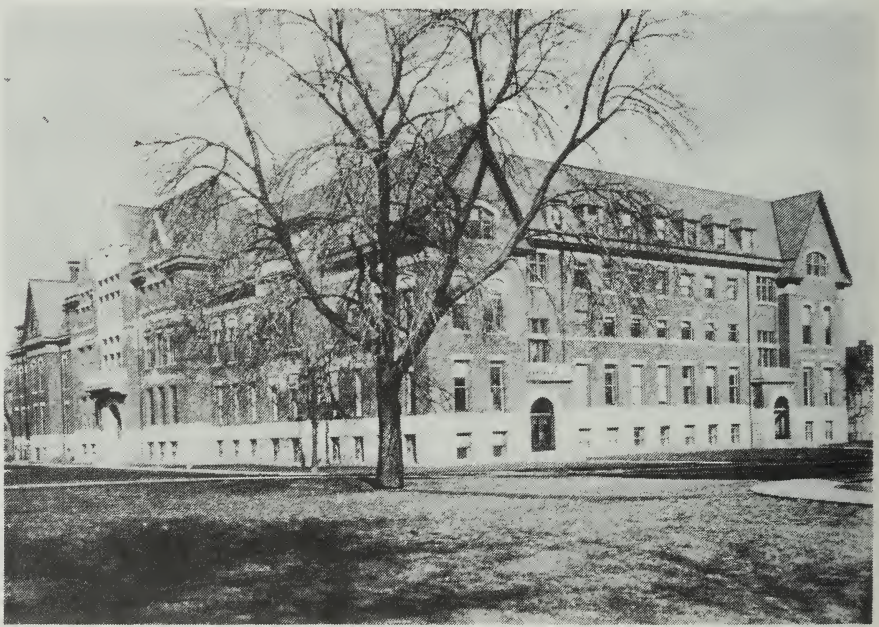
During DeWolf's administration the Geological Survey had moved to successively larger quarters on the campus as its program expanded. From beginnings in a few rooms in the Noyes Chemistry Building, the Survey moved to the Natural History Building in 1909 and in 1916 to the third floor of the Ceramics Building.

From 1916 through 1921, several men joined the staff who subsequently had long and distinguished careers studying the geology of Illinois: J. Marvin Weller, head of the Survey's stratigraphic and paleontological studies for nearly 25 years; and J. E. Lamar and George E. Ekblaw, heads of the Survey's Industrial Minerals and Engineering Geology Sections, respectively, for more than 40 years.

Morris M. Leighton, with doctorate from the University of Chicago and a part time Geological Survey staff member in charge of Pleistocene studies since 1919, resigned from the staff of the University of Illinois and succeeded DeWolf as Chief of the Survey in 1923. At the beginning of Leighton's administration, the staff of the Survey consisted of nine full-time geologists, a chief clerk, and two stenographers. For the summer field season, the Survey employed 15 part-time geologists. The annual appropriation for the 1923-24 biennium was $225,000, which included $100,000 for topographic mapping. The program was based largely on field studies, supplemented by studies of well cutting and cores and some fossil studies in the laboratory. The University of Illinois Department of Chemistry performed chemical analysis of coal for the Survey, and the Department of Ceramic Engineering at the University of Illinois made tests of ceramic clays.

In the first years of his administration, Morris Leighton created several new geological divisions in addition to the Coal Division and Oil and Gas Division established by DeWolf: Non-Fuels, headed by J. E. Lamar, 1924; Subsurface, headed by L. E. Workman, in 1925; Stratigraphy and Paleontology, headed by J. Marvin

**Noyes Chemical Laboratory.** ISGS offices in northwest corner, 1905-1909. (Photo courtesy Univ. Archives, 1907.)



**Natural History Building.** ISGS offices in southwest corner, 1909-1916. (Photo courtesy Univ. Archives, 1916.)

**Ceramics Building.** ISGS offices located on third floor, 1916-1940. (Photo courtesy Univ. Archives, 1920.)

**Turner House Annex and Laboratory.** Used for offices and chemical laboratories to supplement space in the Ceramics Building next door. (Photo, 1931.)

**Participants at Coal Symposium.** 25th anniversary of Geological Survey, April 30-May 1, 1930. Ceramics Building is in background. Leighton, DeWolf, and Bain are in middle of front row.

Weller, in 1926; Engineering Geology, headed by George E. Ekblaw, in 1927; and Educational Extension, headed by Don L. Carroll, in 1929. The creation of the Engineering Geology Section has been cited as the first formal recognition of this specialty field in geology. During these years, two other career scientists, Alfred H. Bell, petroleum geologist, and H. B. Willman, stratigrapher, joined the staff.

During his tenure as Chief, Leighton and his colleagues initiated comprehensive studies of the Pleistocene deposits of the State. These studies brought the Illinois State Geological Survey eminence in research on Pleistocene strata and history.

A state-wide reconnaissance of local road material resources was undertaken by the Geological Survey in 1929-30 at the request of the State Division of Highways. Nine field parties, including such men as Richard Foster Flint, W. C. Krumbein, Harold C. Scott, and F. T. Thwaites, later to become well-known geologists, completed maps for most of the counties of the state, maps which still are valuable sources of information on the location of sand and gravel deposits and limestone exposures.

In 1930 the Geological Survey observed its 25th anniversary with a 2-day program that included a historical summary of geological studies in the state, a survey of the Illinois coal industry and its needs, and a symposium on regional studies of cyclic sedimentation of the Coal Measures strata from Pennsylvania to Texas. The symposium papers, published in the Survey's Bulletin 60, demonstrated that each coal in the Midwest and the East was part of a set of sandstone, mudstone, and, often, limestone beds, deposited in a certain order as the depositional setting, in which the coal was formed, changed from the muddy coast of a shallow tropical sea to a coastal fresh-water tropical swamp. Harold R. Wanless of the University of Illinois and the Geological Survey and J. Marvin Weller subsequently applied the name "cyclothem" to such a set of rock layers. Although somewhat controversial, the cyclothem concept inspired geologists throughout the world to study the coal-bearing rocks in the light of this theory.

Despite the fact that 1930 was a year of economic uncertainty, Leighton, with the support of leaders of the mineral industries, business, and education, proposed a greatly expanded program of multidisciplinary research and service at the Geological Survey, arguing that mineral discovery and technology might stimulate recovery from the depression. In 1931 the General Assembly increased appropriations for the Survey by more than 40 percent, and the Geochemistry, Mineral Economics, and Physics Sections were established. Additional quarters for the Survey adjacent to the Ceramics building were created by acquiring a residence, Turner House, constructing chemical laboratories, and a garage, and attaching a shop to Turner House. For the first time the Survey had facilities to carry on its own geochemical research on the rocks and minerals of the State.

As the Survey's program expanded into new areas of research in 1931, many key personnel were added to the staff: Frank H. Reed and Orin W. Rees in chemistry, Ralph E. Grim in clay mineralogy, Walter H. Voskuil in mineral economics, R. J. Piersoll in physics, and Frederick Squires in petroleum engineering. Glenn C. Finger, in fluorine chemistry, joined the staff in 1933.

The confidence of the state's leaders in the work of the Geological Survey became evident in 1933 when, despite sharp cutbacks in all state agency budgets, a contingency appropriation was made to the Survey to preserve its research program on Illinois mineral resources.

**Natural Resources Building.** Built to house the Geological and Natural History Surveys. Occupied in 1940. Side wings added in 1950.

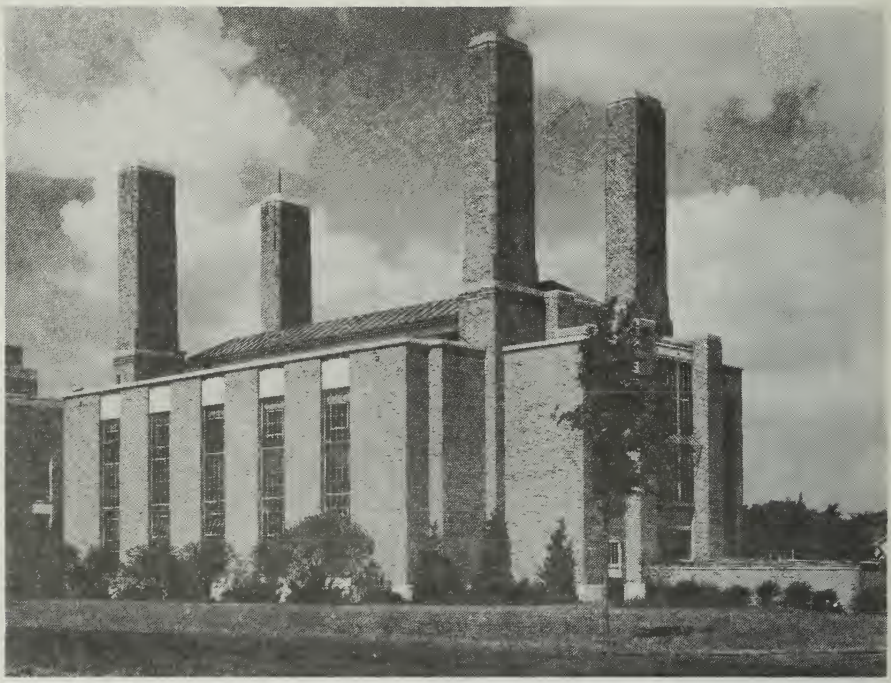
Several benefits to the State resulted from the Survey's research in the thirties. A 1930 Geological Survey map by Alfred H. Bell that classified oil possibilities in Illinois indicated that the deep part of the Illinois Basin (in southeastern Illinois) was the most promising area for oil exploration. At that time there were no oil fields in the deep part of the Basin. In reminiscing about this period, Morris Leighton recalled that he affirmed his confidence in Bell's map to oil interests in the summer of 1936, before any tests were made in the deep basin. In 1937 Pure Oil Company discovered oil in the deep basin, and production of oil in Illinois jumped from fewer than 5 million barrels in 1936 to nearly 150 million barrels in 1940. Survey studies relating to secondary recovery of oil, begun in the 1930s, helped operators begin water flooding of oil fields for increased oil recovery.

The Geological Survey's studies of coal in the 1930s were directed toward delineation of resources, particularly of the Herrin (No. 6) Coal, and physical and chemical properties. The use of electronic equipment for processing of coal data was begun in 1937. ISGS research on coal gained national and international recognition during this period—particularly studies in paleobotany (especially palynology), coal petrology, coal chemistry, and mineral matter in coal. James M. Schopf joined the Coal Division staff for paleobotanical studies in 1935.

Studies of clay mineralogy, begun in 1931 under Ralph E. Grim, Head of the Petrography Division, created new markets for clays, advanced the technology used in mining and manufacturing, and generated solutions to some problems in soil mechanics. Grim and W. F. Bradley of the Geochemistry Section identified and characterized the widespread clay mineral *illite*. The Survey's research in fluorine chemistry, begun in 1934 by Glenn C. Finger, resulted in the development of several new fluorine compounds and practical techniques for producing many fluorine compounds. The research also demonstrated the unusual properties and suggested possible uses of these compounds. In response to requests, fluorine compounds were sent to laboratories throughout the United States for testing in industrial uses, drugs, and pesticides. By 1939 the value of the State's mineral production had risen to 283 million dollars.

In 1940 the Geological Survey moved from its quarters in the Ceramics Building to the new Natural Resources Building, built for the Geological and Natural History Surveys with a State appropriation and a Federal grant obtained with the support of Governor Henry Horner, the mineral industry, and other supporters of the Survey. As part of the dedication ceremonies for the new building, an Illinois Minerals Industry Conference was held November 14-16, 1940. By the following spring the laboratories in the new building were fully equipped. An Applied Laboratory for the Survey's coal studies was also completed in 1941. Here research was carried on to investigate ways to blend Illinois coals to produce metallurgical coke, with pilot scale testing to produce smokeless briquettes.

The Survey's new laboratories were completed only nine months before the United States entered World War II. After the United States entered the war, the Illinois Geological Survey was mobilized for a number of war efforts. The ISGS provided a fluorine compound, together with specifications for its preparation and purification, for the Manhattan Project for the development of the atomic bomb. With support from the U. S. Office of Production Research and Development, the Geological Survey continued



**Applied Research Laboratory.** Completed in 1941.

**Natural Resources Annex Building.** Building completed in 1972 and is shared with Natural History Survey. View shows only the portion of the building that houses the Geological Samples Library.

**Mobile laboratory.** Survey geologists, Coal Section, study drill cuttings from oil exploration holes for coal investigation during World War II.

**ISGS field office.** The DeSoto Hotel, Galena, Illinois, provided field offices during investigation for lead and zinc during World War II. Robert R. Reynolds and Paul Herbert, Jr. are on left.

its study of the feasibility of blending Illinois coals with Eastern coals in making metallurgical coke. By 1944, blends of Illinois and Eastern coals had been coked successfully and provided a substantial new market for Illinois coal in the Illinois steel industry. By substituting some Illinois coal for Eastern coal in metallurgical coke, the freight requirement for transporting Eastern coal to Illinois was reduced by more than 2 million freight car miles by the end of the war.

Special appropriations were made for emergency studies of ground-water geology, particularly in northeastern Illinois where war-related manufacturing was placing a heavy demand on water resources. The use of electrical earth resistivity surveying and of exploration tools from the oil industry such as geophysical logging was developed and expanded in connection with ground-water studies from the early forties. M. King Hubbert had pioneered electrical earth resistivity studies in Illinois for the ISGS in the early 1930s. A significant product of the ground-water studies was a report and map on the bedrock topography of Illinois by Leland Horberg, published in 1950. Emergency studies were supported during the war years for oil and gas resources in the Illinois Basin, for fluorspar deposits in Hardin and Pope Counties, and for lead and zinc deposits in northwestern Illinois. The Geological Survey operated a branch office in Galena for assisting lead and zinc exploration.

Beginning in 1945, Leighton and the Geological Survey participated in the work of the Illinois Post-war Planning Commission. In 1945 the Commission published an atlas on *Illinois Resources* for which the Geological Survey provided the material on mineral resources. Partly as a result of the Commission's recommendations for new state buildings, new wings for the Natural Resources Building were completed in 1950, bringing the building to its present form. In 1950, appropriations for the Geological Survey totaled about 710 thousand dollars. In the same year, the state mineral production had climbed to about 500 million dollars.

In 1954 Morris Leighton retired as Chief of the Geological Survey and was succeeded by John C. Frye, former State Geologist of Kansas, and, like Leighton, a Pleistocene geologist. At the 50th anniversary of the Geological Survey the following year the Chief reported that the full-time technical ISGS staff consisted of 48 geologists, 22 chemists and physicists, 4 engineers, 2 mineral economists, 2 editors, 2 photographers, a librarian, and 30 research and technical assistants, a total of 111. The nontechnical staff consisted of 20 persons.

Chief Frye maintained the high level of support for much of the research that had evolved under his predecessors. He and H. B. Willman and others continued and expanded basic studies of the Pleistocene of Illinois, which resulted eventually in a reclassification of the Pleistocene of the State. In 1957 he brought Hubert E. Risser to the staff of the Mineral Economics Division. He also initiated some new Survey programs. During the next 10 years the Geological Survey and the Water Survey cooperated in several investigations that resulted in major publications on the ground-water resources of northeastern Illinois, DuPage County, and the Havana region. In 1959, to facilitate ground-water investigations and serve the growing suburban development in northeastern Illinois, a field office was opened in Naperville. (This office was later moved to Warrenville.) Partly in response to a variety of inquiries reaching this field office, a program of geologic research and service evolved for which a new term,

"environmental geology," was coined at the Survey in 1963. Environmental geology is the application of geologic data and principles to problems created by human occupancy of land and development of natural resources, with the goal of promoting efficient and safe uses of the physical environment. The ISGS program dealt with many problems of urban areas: solid-waste disposal, construction and drainage conditions, surface mining, land-use planning, and water and mineral resources. In 1965 a series called *Environmental Geology Notes* was begun to disseminate information resulting from Survey research. During the next 5 years many geological agencies throughout the world initiated environmental geology programs.

During the 1960s and 1970s, growing environmental concerns prompted citizens and representatives of industry and government agencies to call on the Survey more frequently for geologic information. Research was begun on earth materials and processes involved in the disposal of solid and liquid wastes from cities, industries, and mines. In response to a national search, the Survey's assessment of the geologic conditions of a number of sites in northeastern Illinois contributed to the selection of a site near Batavia, Illinois, for the establishment of the National Accelerator (now Fermi) Laboratory in 1966. A radiocarbon dating laboratory was established in 1968 in support of the Survey's basic and applied studies of the Pleistocene deposits of the State. Concern about the pollution of Lake Michigan and shore damage caused during a period of high lake level in the early seventies led to a study of bottom sediments and shore processes. A field station for studying Lake Michigan was maintained at Illinois Beach State Park from 1974 to 1977.

As awareness of energy problems increased in the seventies, Geological Survey activities focused on mapping coal reserves, investigating the uses of by-products of coal processing and conversion, increasing the knowledge of coal mining geology, seeking unconventional sources of gas and oil, and evaluating the geology of potential nuclear power plant sites. Studies of the constituents of coal, natural gas, and mineral wastes—many present in only trace amounts—were facilitated by a growing array of analytical instruments. Access to University of Illinois facilities and equipment, such as the TRIGA nuclear reactor, scanning electron microscope and probe, and mass spectrometer, increased the Survey's research capabilities. In the late sixties and in the seventies the Survey staff developed ILLIMAP, a computer-based system for constructing maps of the state and plotting data. The Geological Survey acquired computer equipment and a terminal for access to the computer facilities of the University of Illinois.

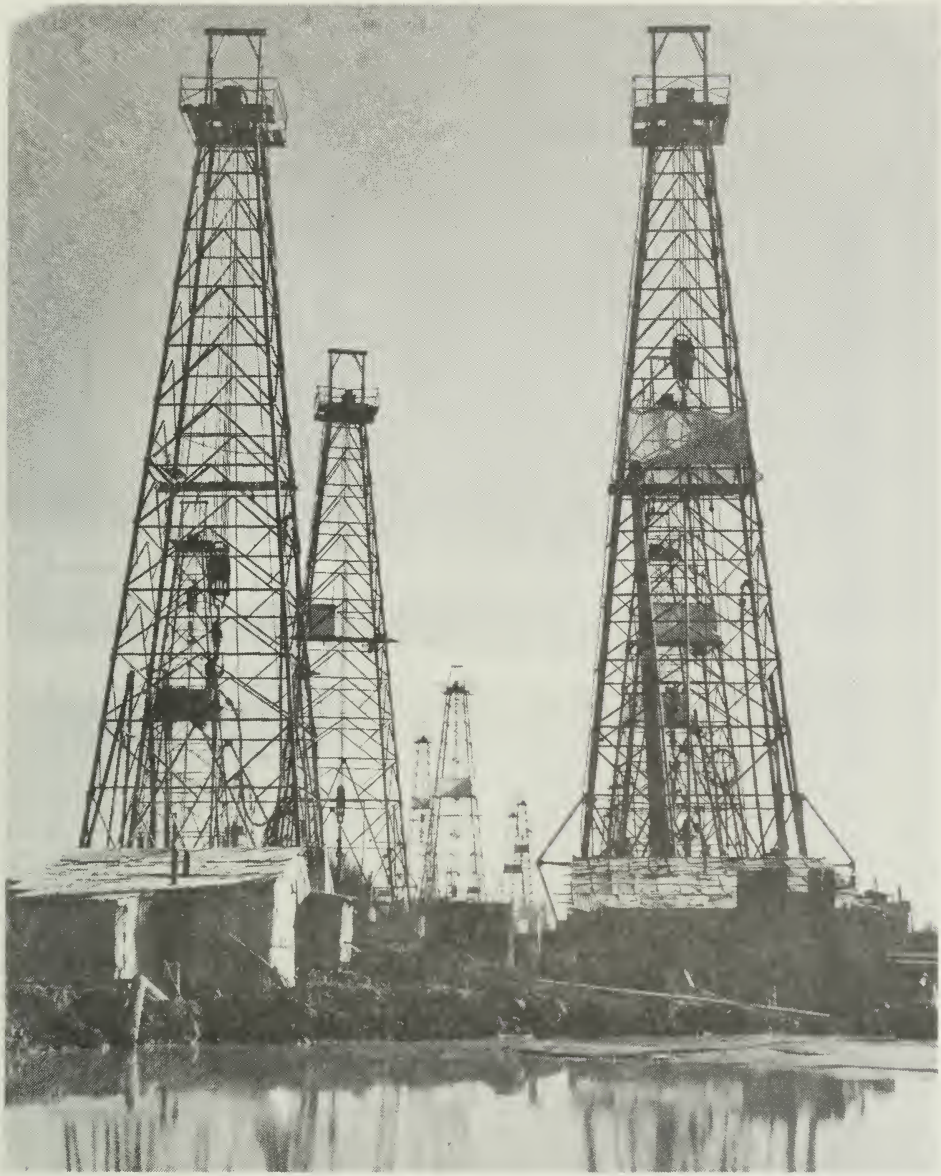
In 1973 the Geological Survey and the Natural History Survey jointly occupied a new building, the Natural Resources Studies Annex, built with a special state appropriation. The Geological Survey's part of the building houses principally the Geological Samples Library, a collection of drill cuttings, cores, and rock and mineral samples, and now includes cuttings from about 62,000 drill holes and cores from about 12,000 drill holes. The annex also houses supporting laboratories and many paleontological collections.

The mineral industry of Illinois continued to expand, and appropriations to the Geological Survey increased during the administration of Chief Frye. The mineral industry yielded products worth 716 million dollars in 1970; appropriations to the

Geological Survey in 1970 totaled 2.35 million dollars. The regular staff in 1970 consisted of 50 geologists, 20 chemists, 5 engineers, 3 mineral economists, 38 reasearch and techinical assistants, 3 editors, 1 librarian, 1 photographer, 35 non-technical personnel, plus students and temporary help.

In 1974 Frye retired, after serving 20 years as Chief. He was the fourth head of the Survey in its approximately 70-year history. He was succeeded by Jack A. Simon, former Principal Geologist and earlier Head of the Coal Section, whose initial appointment to the Geological Survey was in 1937. In 1979 another state reorganization occurred and the Geological Survey, Natural History Survey, and Water Survey became divisions of a newly created Institute of Natural Resources, which also includes the State Museum and divisions concerned with energy and environmental quality.

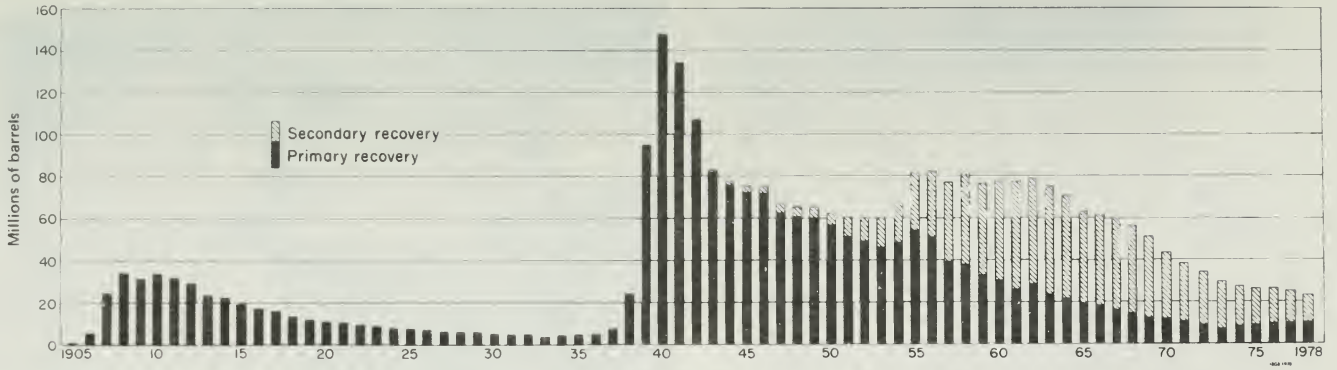
Since the seventies (particularly during the latter half), the Survey's research program has been increasingly supported by contracts with other agencies such as the U. S. Bureau of Mines, the U. S. Department of Energy, the U. S. Environmental Protection Agency, the U. S. Nuclear Regulatory Commission, and the U. S. Geological Survey. Some research support has also come from other State agencies. Through an agreement between the Board of Natural Resources and Conservation and the Board of Trustees of the Universtiy of Illinois, the University accepts funds from such agencies for research to be carried out under direction of the State Geological Survey.



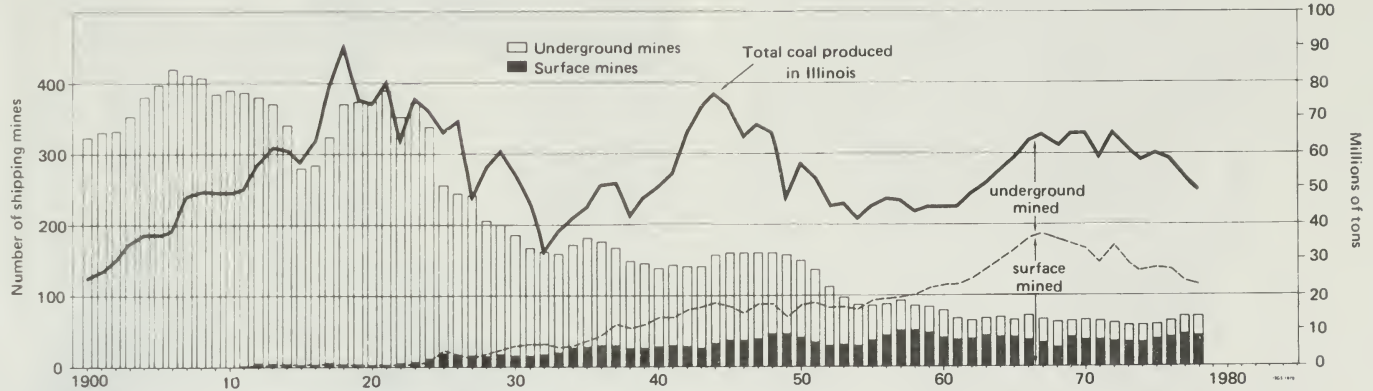
**Early oil discoveries in Illinois Basin.** Rotary rigs drilling in Salem Oil Field, Marion County, Illinois. Discovery well was drilled in 1938, shortly after oil was discovered in deep part of Basin. (Photo, 1943.)


*Before 1970 clay products were used in the total; from 1970 to the present raw clay was used.

Value of mineral production in Illinois, 1917-1979.




Annual crude oil production in Illinois, 1905-1978.




Trends in coal production in Illinois, 1900-1978. (Source: Illinois State Department of Mines and Minerals, Annual Coal, Oil, and Gas Reports.)

**Electrical earth resistivity survey.** Keros Cartwright and Merlyn B. Buhle search for water-bearing sand and gravel deposits. (Photo, 1967.)

**Drill core study.** Donald B. Saxby, left; Elwood Atherton, right. (Photo, 1952.)

## RESEARCH AND PUBLIC SERVICE

The Illinois Geological Survey is charged with studying the geology and mineral resources of the State and reporting the results of these studies to its citizens. Research and public service are thus key elements in the Survey's program.

Results of ISGS studies are reported to the public, to industry, and to local, state, and federal governmental agencies through publications, correspondence, press releases, exhibits, and personal contacts. Among the publications series issued by the Geological Survey are Bulletins, Reports of Investigations, Circulars, Illinois Petroleum Series, Educational Series, Environmental Geology Notes, Illinois Minerals Notes, Guidebook Series, and Map Series. In addition, staff members of the Geological Survey annually answer many thousands of inquiries by letter, telephone, and conference.

Research and public service fall into three general categories: (1) mineral resources, (2) environmental geology and geochemistry, and (3) basic geology and geochemistry.

### Mineral resources

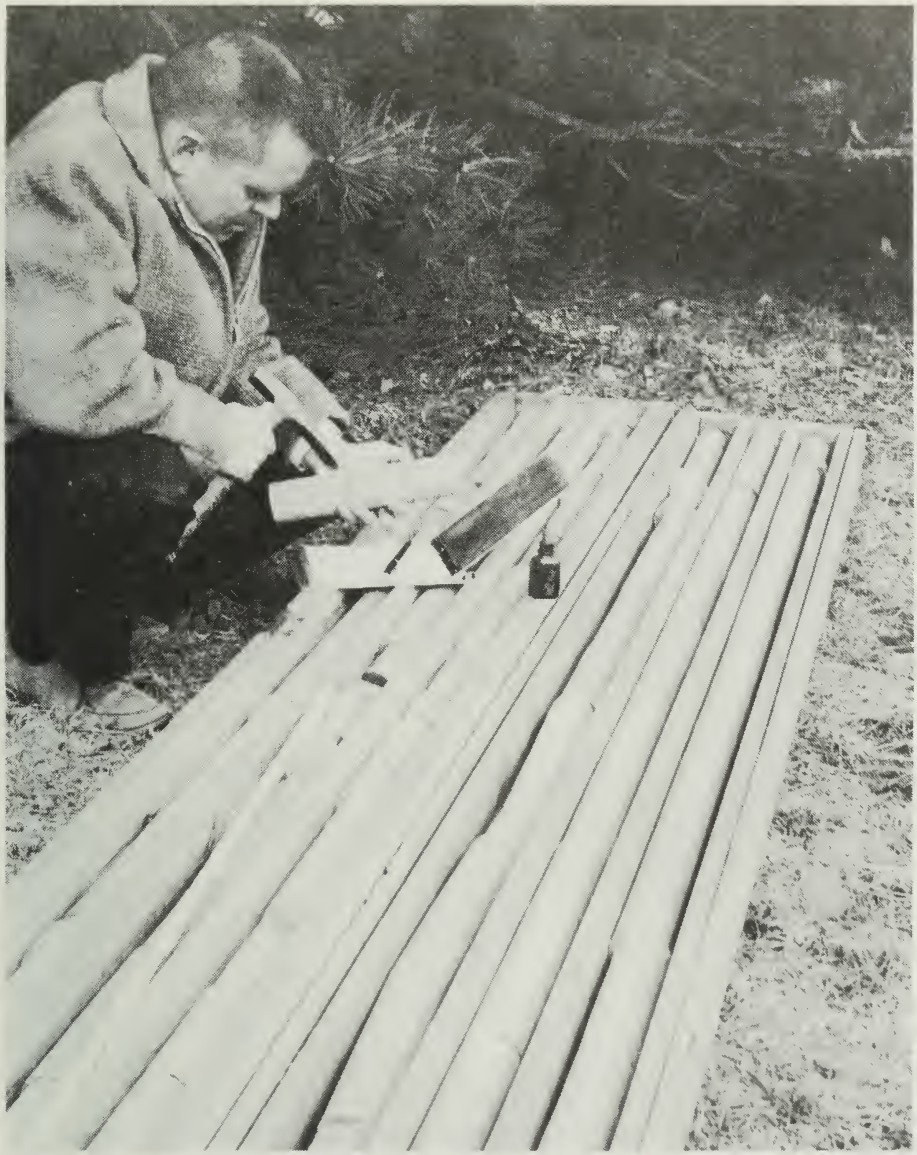
Mineral resources in Illinois include coal, oil and gas, limestone and dolostone, sand and gravel, clay, fluorspar, tripoli, lead and zinc, peat, gemstones, and barite, which in 1979 yielded a value to the state of more than 2 billion dollars. In 1978, Illinois led the nation in the production of fluorspar and tripoli, was third in the production of crushed stone and peat, fifth in the production of coal, sixth in the production of sand and gravel, and sixteenth in the production of oil and gas. Mineral materials were produced in 99 of the state's 102 counties. In 1979, 22 Illinois counties mined 59.6 million tons of coal valued at 1.4 billion dollars, and 43 counties produced 21.8 million barrels of oil, valued at 436 million dollars. Fifteen million barrels of oil, or 57 percent, were produced by secondary-recovery methods, mainly by water flooding. The Geological Survey publishes annual reports on all mineral production and on the oil and gas industry in the state.

The distribution, origin, and the physical and chemical properties of these resources are studied within the Coal, Oil and Gas, Industrial Minerals, Analytical Chemistry, and Geochemistry Sections of the Survey. The Mineral Engineering section studies processing, uses, and means of improving the quality (beneficiation) of the mineral resources.

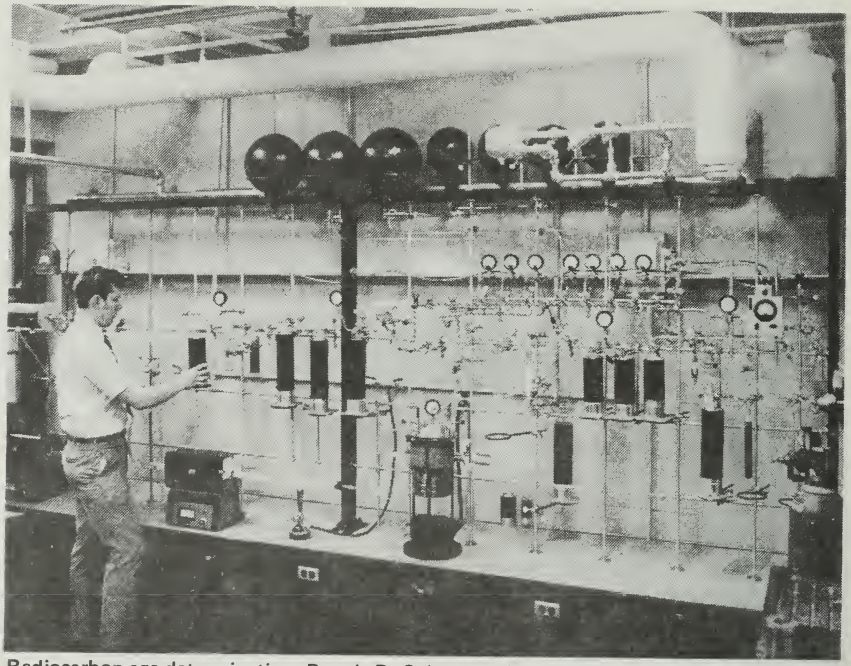
Mapping and analyzing the state's coal resources and cooperating with the coal industry have been major activities of the Geological Survey since its founding. The mapping has resulted in the delineation of more than 161 billion tons of coal resources in the ground. Studies in progress classify 50 billion tons as recoverable reserves using present underground or surface mining practices. Extensive sampling of coals in the field provide the basis for broad studies of the constitution of coal, including coal quality, beneficiation, mineral matter, coal petrology, paleobotany and chemical and physical properties. Determinations of mineral matter in coal, including potentially valuable metals and potential pollutants in waste products, are facilitated by new advances in analytical techniques and by low-temperature ashing of coal with an oxygen-rich plasma—a technology pioneered for coal studies at the Geological Survey in the 1960s.

**Pushing coke charge from pilot coke oven.** B. J. Greenwood at Applied Research Laboratory. (Photo, 1956.)

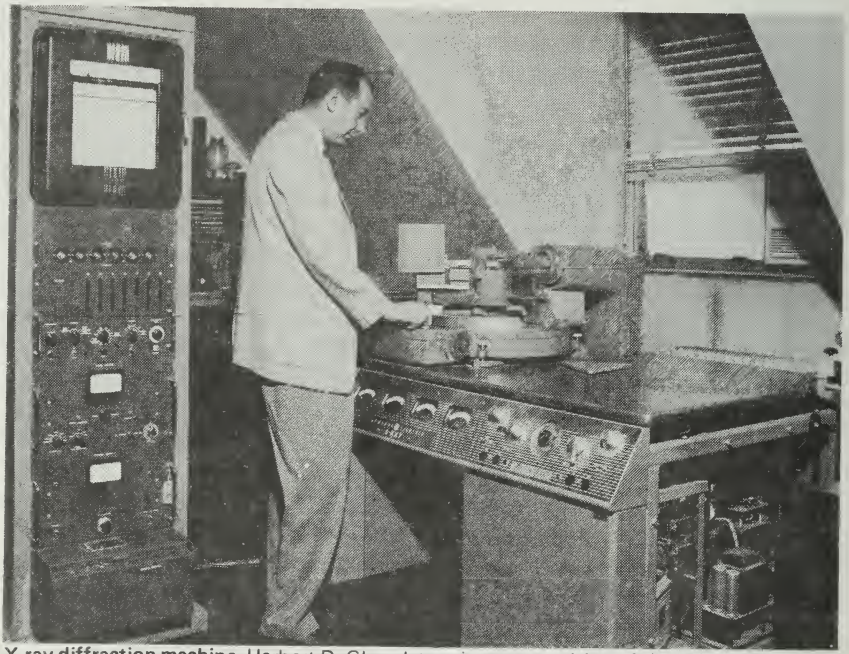
**Examining fossils from paleontological collection.** Lois S. Kent, Curator at Geological Survey. (Photo, 1965.)



**Logging core from coal exploration hole.** M. E. Hopkins, Coal Section. (Photo, 1965.)

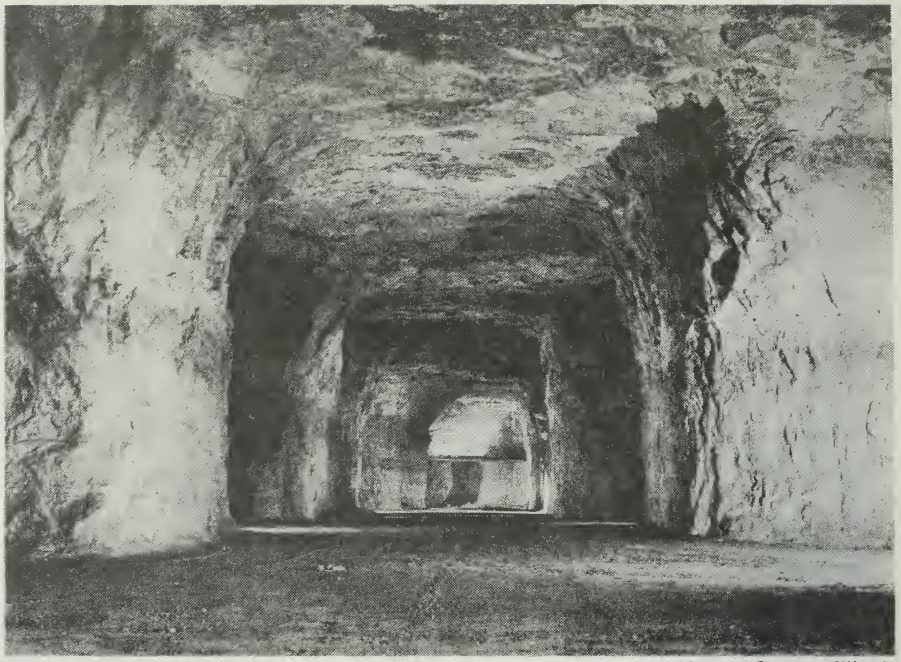


**Radiocarbon age determination.** Dennis D. Coleman using benzene synthesis train. (Photo, 1971.)



**X-ray diffraction machine.** Herbert D. Glass determines composition of clay minerals. (Photo, 1960.)

**Binocular microscope.** Thomas C. Buschbach studies drill cuttings from a deep well. (Photo, 1959.)



**Underground limestone mine.** Columbia Quarry Company near Valmeyer, Monroe County, Illinois. (Photo, 1957.)

**Hydraulic mining of silica sand.** Pit owned by Standard Silica Corporation is located near Ottawa, Illinois. (Photo, 1954.)

Data on reserves, constitution, and properties of coal are being put into a Coal Data System for rapid retrieval and analysis of coal information.

Detailed investigations of stratigraphy and structure and other geologic features related to mining problems in underground coal mines yield information useful in planning mining operations and in understanding the mechanics of surface subsidence. Research on utilization of coal includes study of coking properties, investigation of the forms and distribution of sulfur and other undesirable constituents in coal, and physical and chemical ways to reduce these constituents.

Studies relating to oil and gas have focused on the geologic occurrence of oil and gas and the production histories of known pools. Regional stratigraphic and structural investigations now being carried on within the Oil and Gas Section may be just as relevant to future development of Illinois petroleum potential as were the ISGS studies in the 1930s. In response to demands for new sources of energy, the Survey has been conducting major ecologic and geochemical studies relating to unconventional sources of gas such as the black shales of Mississippian-Devonian age.

For more than 25 years the Geological Survey has cooperated with industry by providing geologic data for evaluating and developing underground facilities for the storage of natural gas. More recently the Survey has conducted exploratory studies for underground pumped storage and air injection for generating power for peaking in electric generation.

The Survey's research program includes studies of the constitution of oil and gas. Determinations of the ratios of oxygen isotopes in gas, especially methane, yield clues about the origin of the gas, for example, whether the gas is from a natural source or from a sanitary landfill or leaking pipeline or storage reservoir.

Industrial minerals research focuses on the occurrence, properties, and uses of Illinois rocks and minerals such as limestone and dolomite, sand and gravel, sandstone, clay, tripoli, fluorspar, lead, and zinc. Clay mineralogy and factors influencing utilization of clays are major areas of study. Physical and chemical properties of carbonates are studies relative to a variety of uses, and long-term studies of fluorine chemistry have been conducted to promote the nationally important deposits of fluorite, the State mineral.

The Hydrogeology and Geophysics Section conducts some of its studies of groundwater geology in cooperation with the State Water Survey. The ISGS studies are concerned with the distribution and properties of aquifers (water-yielding deposits), which in Illinois occur in glacial drift and also in underlying bedrock. Electrical earth resistivity surveys are conducted by the Geological Survey to locate deposits of water-yielding sand and gravel in the glacial drift.

**Environmental geology and geochemistry**

From very early in its history, the Geological Survey has been involved with the application of geologic knowledge to problems connected with the human use of the land. The formation of the Engineering Geology Division in 1927 was an early recognition of the need to provide geologic data for the design and construction of dams and reservoirs, highways, and buildings. The ISGS *Environmental Geology Notes* series

**Entrance to Cave in Rock.** J Harlen Bretz, University of Chicago, at cave in Hardin County, Illinois. (Photo, 1959.)

**Shawneetown Fault.** Upturned beds of Mississippian limestone near Horseshoe, Saline County, Illinois. (Photo, 1952.)

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provides a way of informing the public about the results of this research. So far, 88 EGN reports have been issued.

A major focus of the environmental geology program is research and service on the disposal of wastes—municipal refuse, industrial waste (including liquids and hazardous chemicals), and mining and mineral processing waste. The Survey provides hydrogeologic information for evaluation of disposal sites and geologic and geochemical data on capabilities of various earth materials which may reduce the potency of contaminants released from buried wastes.

Geologic hazards resulting from natural processes and man-made conditions which affect land use are studied by the Survey. Landslides and other types of instability on steep slopes are investigated and monitored, and subsidence of the land surface over underground mines (commonly resulting in damage to buildings, roads, and utility lines) is currently under intensive investigation. The Survey provides information on bedrock structure, stratigraphy, hydrogeology, seismicity, and possible geologic hazards for site investigations, such as for nuclear power stations and other major facilities.

Another major activity in the environmental geology program is the study of the sediments and shore processes of Lake Michigan, which affect man's activities along the shore.

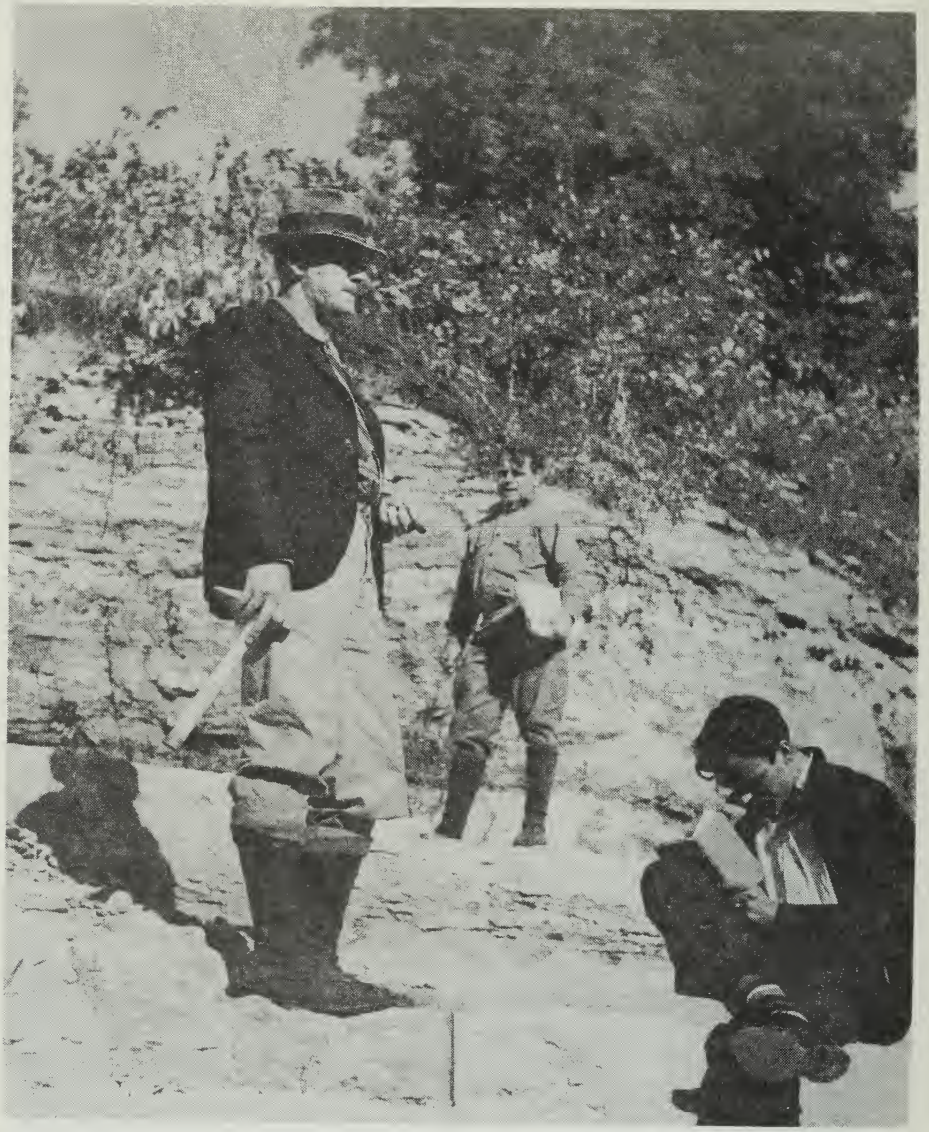
Geochemical studies in the environmental program are concerned with potential pollutants such as sulfur and trace metals in natural earth materials and processed materials and with the occurrence and mobility of various pollutants in municipal and industrial wastes.

**Basic geology and geochemistry**

The Geological Survey is the repository of data on geology and mineral resources of Illinois, and a major effort is directed toward collecting and processing these data and making them available to the public. About 250,000 records from oil and gas wells, water wells, coal borings, mineral exploration tests, and foundation borings are on file in the Survey's Geological Records Section. The Geological Samples Library contains cuttings and cores from nearly 75,000 of these drill holes. Paleontological collections, some dating back to the first Illinois Geological Survey, are available for internal use and for loan in research. Many thousands of items of chemical analytical data on many of the earth materials of Illinois are on file.

The Geological Survey also maintains a map library where a wide variety of maps, geologic field notes, photographs, and unpublished manuscripts are on open file. The Survey is the state agency designated to cooperate with the U. S. Geological Survey for topographic mapping in Illinois.

Although the Stratigraphy and Areal Geology Section of the Survey conducts most of the basic research on stratigraphy, structure, and paleontology of Illinois, this research is supplemented by work done in several other sections. For instance, the Coal Section conducts studies of Pennsylvanian stratigraphy and paleobotany; the Oil and Gas and Industrial Mineral Sections conduct studies of Mississippian stratigraphy and structure; and several sections are studying the Pleistocene deposits. Geologic mapping



**Earth science field trip.** George E. Ekblaw, Head of Engineering Geology Section, at Pere Marquette State Park, September 30, 1939.

is conducted by most of the sections, often as a basis for applied uses. A map published in 1979, complementing the map of the bedrock geology of the state, shows the surficial deposits (the Quaternary deposits) of the state at a scale of 1:500,000.

The concern that nuclear power stations be located on stable ground away from earthquake-prone areas has led to the Survey's investigation of faults, deep structure, geologic history, and seismicity with the objective of determining earth mechanics and judging potential risk from earthquakes. The Geological Survey is cooperating in this investigation with other Surveys and institutions situated in states within 200 miles of New Madrid, Missouri, which was the center of severe earthquakes in 1811-12.

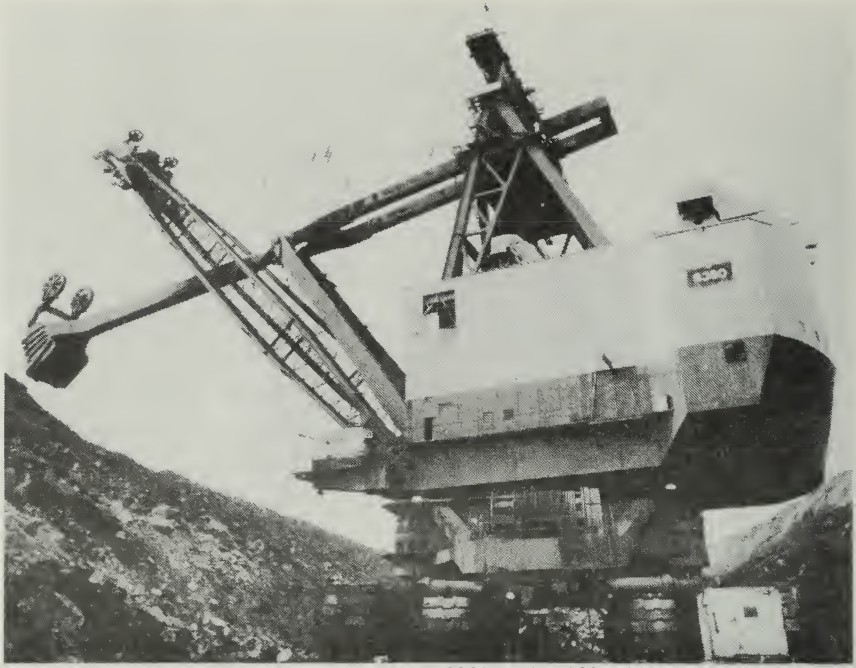
Geophysics—including electrical earth resistivity, gravity, magnetics, refraction and reflection seismography—is used both for basic studies of rocks and earth structure and for applied uses. The Survey operates a modern geophysical logger for logging drill holes. A radiocarbon laboratory makes age determinations of earth and archeological materials to a maximum age of about 50,000 years. Within the Chemical Group, basic studies include development of improved methods of analyzing earth materials.

### Other Activities

Through its program of educational extension, the Geological Survey provides information and other instructional materials about the state's geology and mineral resources to elementary, high school, and college science teachers, and other groups. Since 1930 geological science field trips to various areas in the state have been conducted in the spring and fall for teachers of earth science, students and public.

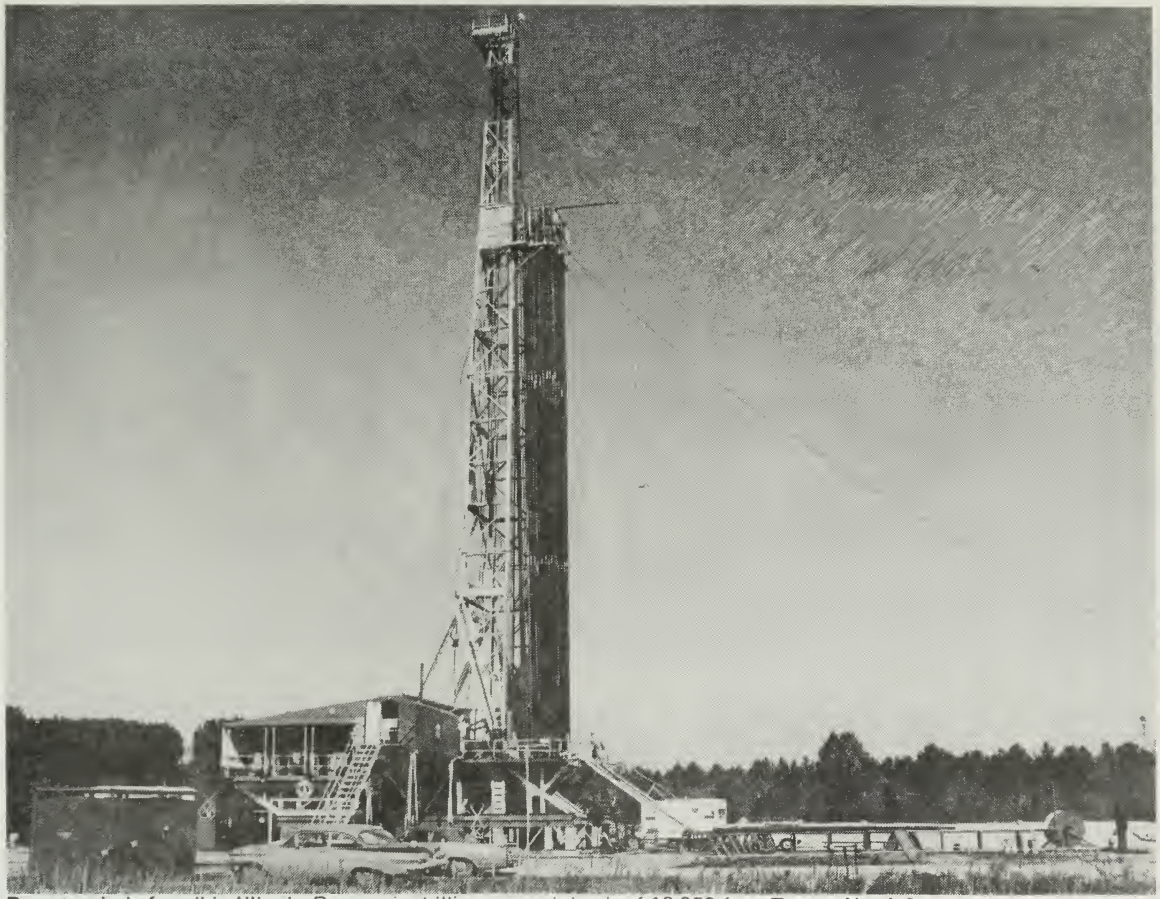
The Geological Survey maintains a research library containing books and periodicals on geology, chemistry, mineral resources, and related subjects and operates, through the University of Illinois, a program of exchange and distribution of its publications with 405 libraries and other institutions in 63 countries. The library contains about 70,000 documents including 3,800 books and 15,000 bound volumes representing 285 series. Among the library's holdings are all the publications of the Illinois State Geological Survey (some 5,000 reports).

The Illinois Geological Survey is a distribution center for U. S. Geological Survey topographic maps, base maps, orthophotoquads, and flood-prone-area maps of Illinois. Topographic maps of all of Illinois are available at a scale of 1 inch equals approximately 1 mile (15-minute series) or 1 inch equals 2,000 feet (7.5-minute series). Mapping of the state in the 7.5-minute series is about 60 percent complete.

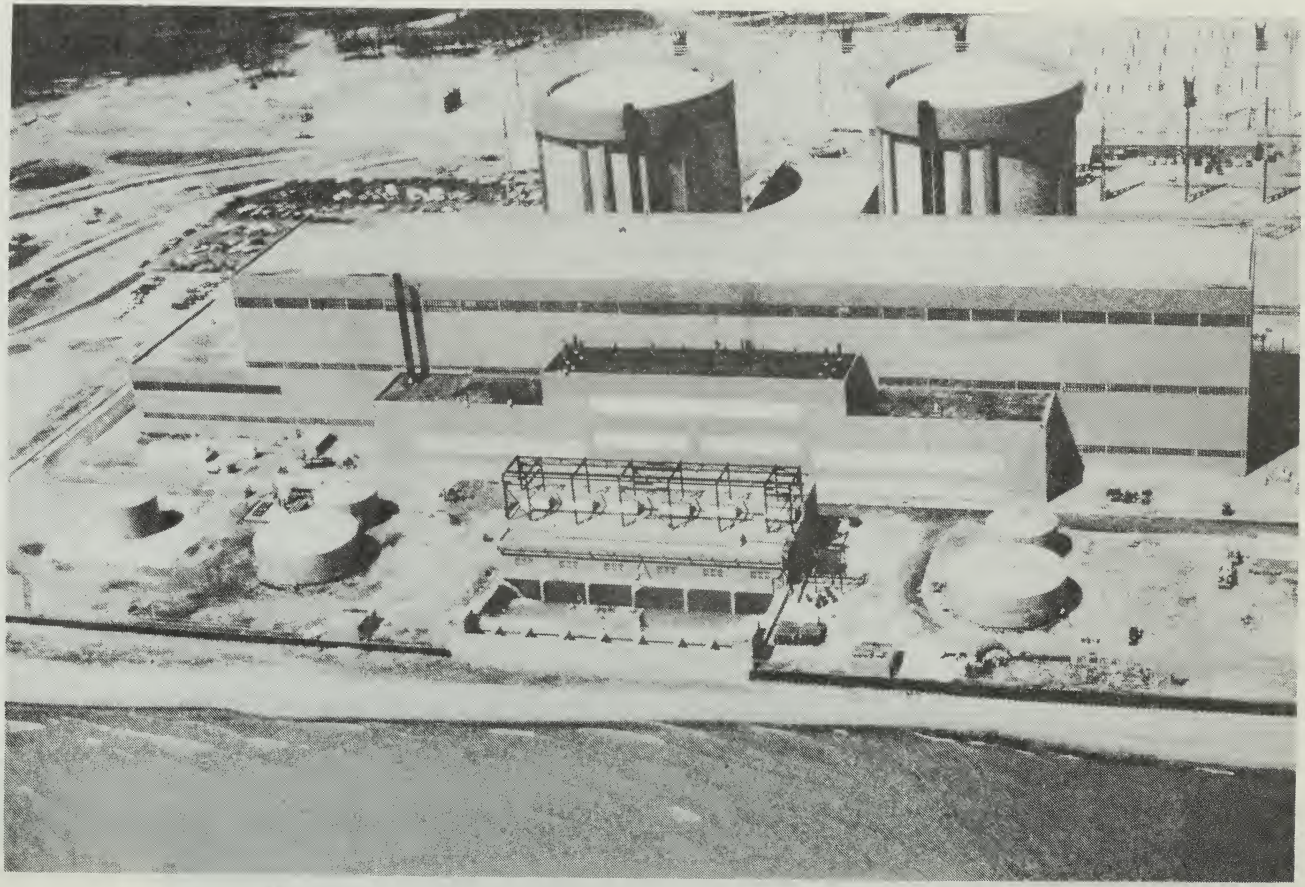


**Largest coal shovel in world.** Marion Coal Shovel 6360, with a 180-cubic yard bucket, operating in Captain Mine of Southwestern Coal Company, near Percy, Illinois. (Photo courtesy Arch Mineral Corporation.)


**Bucket wheel excavator.** Used in strip mine of Peabody Coal Company near Wilmington, Illinois. (Photo, 1967.)



**Deep test hole for oil in Illinois.** Rotary rig drilling to total depth of 13,050 feet, Texaco No. 1 Cuppy, Hamilton County, Illinois. (Photo, 1965.)



**Nuclear power station.** Commonwealth Edison plant at Zion, Illinois. (Photo, 1976.)

## THE YEARS AHEAD

As previously noted, the first Geological Survey of Illinois was discontinued in 1875 when the State General Assembly considered that the geological study of the state was complete. Yet, after 75 years of study by the second State Geological Survey, problems continue to arise requiring new data on the geology of Illinois, and the search for and the development of mineral resources go on.

In the past 10 years it has become increasingly obvious that our nation's mineral resources, particularly our developed energy resources, are not infinite, and that we must find new resources and use known ones more effectively. It has also become obvious that certain practices in manufacturing, mining, transportation, and urban development have produced undesirable impacts on water, air, and land. The nation's response to this discovery was widespread mobilization in defense of the environment in the sixties and seventies, followed by the enactment of stringent regulations to protect the environment. Today national goals are focused both on increasing our energy resources and protecting the environment—goals that have produced some conflict when pursued independently.

In the years ahead the Illinois Geological Survey will face the challenge of contributing to the resolution of this conflict. A major part of the geological research and services at the Survey will be concerned with the following broad goals: more efficient uses of minerals and land; increased development of underground mining of some mineral products, such as limestone; greater use of underground space; development of unconventional sources of gas; safe disposal of hazardous wastes; greater public awareness of the role of geology in mineral and environmental problems; and greater use of geological data and counsel by all sectors affected by increasingly strict environmental regulations.

In facing the challenges ahead in energy and environment, the present staff considers itself fortunate to have inherited a tradition of excellence in science and public service established by past members of the Illinois State Geological Survey.

**ILLINOIS STATE GEOLOGICAL SURVEY** Urbana, Illinois October 1, 1980
Full Time &
Permanent Part-Time

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Robert E. Bergstrom, Ph.D., Assistant Chief

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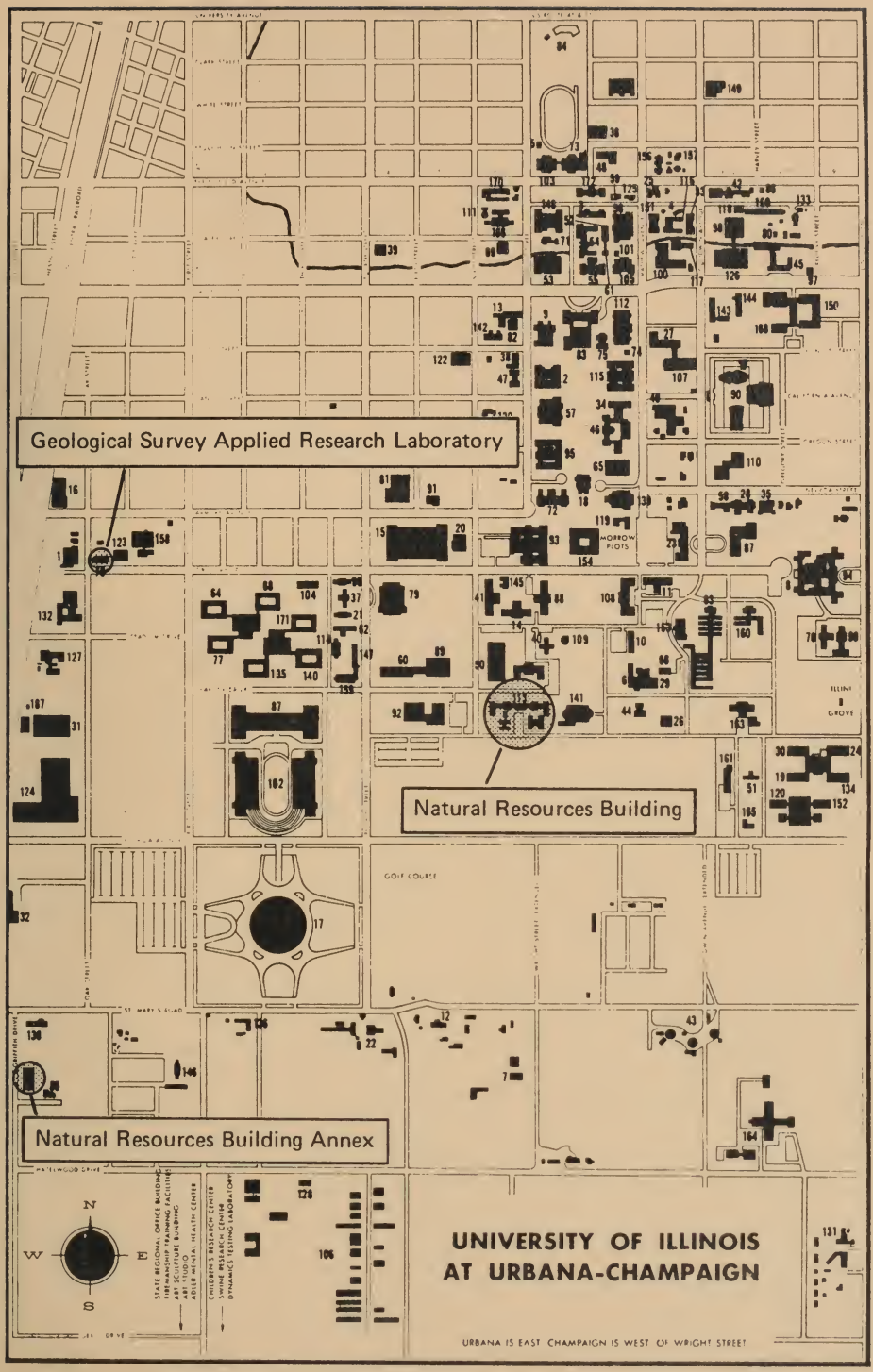
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